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Hans Henrik Andersen

1. May 1937 – 3. November 2012.

With Hans Henrik Andersen, emeritus professor of Physics at the University of Copenhagen, a pioneer of ion-beam physics and founding editor of Nuclear Instruments and Methods B (NIMB), has left us. Hans Henrik was one of the leading experimentalists in the field of particle-solid interactions and widely respected for his experience and judgement.

One of his most original and influential achievements goes back to his PhD thesis under Hans Sørensen at Risø, the research center of the (then) Danish Atomic Energy Commission, where he had the idea to measure particle stopping calorimetrically at liquid-helium temperature. This gave rise to data with an accuracy not seen before in this area. Even now, half a century later, these data still are state-of-the-art. Actually, early in the development a comparison was made between the energy losses of protons and deuterons in a thin metal foil. Surprisingly this revealed a significant difference which was not predicted by theory. After a systematic search for all possibly disturbing effects, the problem was found to originate in the energy calibration of the newly acquired tandem accelerator where the measurements had been made. From then on, nuclear physicists stopped expressing doubts about the usefulness of atomic-physics measurements at a tandem machine!

A few years later a systematic deviation from Bethe's famous stopping formula was found when the energy loss of alpha particles was compared with that of protons. There was no doubt that this effect was real, and it was related to a similar difference which had been found by Barkas and coworkers between mesons of positive and negative charge, back in the early 1950s. This effect, subsequently called Barkas effect, ought to be called Barkas-Andersen effect, considering that Hans Henrik's discovery, which was possible only because of an experimental accuracy of ~ 1 pct., opened up for a major theoretical and experimental activity. Now, more than forty years later, we know that the difference between the energy loss of protons and antiprotons can amount to as much as 50 per cent.

After finishing his PhD and military service Hans Henrik moved to Aarhus University, where he had a particularly creative period as a researcher, at the same time being a teacher and administrator. While being in charge of introductory physics courses, dean of the science faculty for several years and member of the Danish Science Research Council, he was active in the laboratory, made efficient use of several accelerators and became the advisor of numerous successful MSc and PhD students.

While continuing his work on particle stopping, in particular with his student Bjarne R. Nielsen, he carried out systematic measurements on multiple scattering of ion beams with J. Böttiger and his student H. Knudsen and took an active role in the development of ion sources with Per Tykesson and Jan Heinemeier. Yet his main contribution in those years was an ambitious program to experimentally study sputtering from material surfaces by ion bombardment. This phenomenon had been around for more than a hundred years, but characteristically for Hans Henrik, he had studied the entire experimental and theoretical literature, so he could start at the point where predecessors, notably Gottfried Wehner and Olle Almén, had stopped.

His first achievement in this area dates back to 1968, where he confirmed, by calorimetry, a theoretical prediction of the energy reflection coefficient in self-ion bombardment. Following up on this success he built up, together with his student H. L. Bay, a setup to measure sputter yields via the loss of mass by a target mounted on a quartz microbalance. These measurements did not only produce a wealth of data but also provided important systematic information on the dependence of sputter erosion on ion fluence. A distinction had to be made between sputtering on a target saturated with implanted beam atoms and a virgin target (which was not really virgin at the time because of the absence of ultrahigh vacuum).

Having learned this, Hans Henrik was ready to study the sputtering of multiple-component materials, mostly alloys. There had been previous attempts, all ending up in the conclusion that this was a rather complex phenomenon. A particularly puzzling feature was the fact that changes in stoichiometry seemed to extend much deeper into the target than what was thought to be the depth of origin of sputtered atoms. This is not the place to sketch this development, which is still not finished today. However, Hans Henrik's contribution to the area is paramount both on the experimental and the theoretical side. In addition to yield measurements, studies of the angular distribution of emitted species became particularly

informative. He also provided an illuminating theoretical estimate of atomic mixing by ion bombardment in an attempt to determine the depth resolution of sputter profiling.

The idea of sputtering being a result of evaporation from a heated region had been around for a century but was out of fashion in the 1960s in view of the success of collision cascade theory. Here, Hans Henrik had the idea to compare sputter yields by bombardment with a molecular ion with that for an atomic ion at the same velocity. If sputtering was a linear process, bombardment with a diatomic molecule had to produce twice the sputter yield. The measurements, reported at a conference on sputtering in 1972, showed a clear enhancement in case of heavy ions.

This finding started a wealth of experimental and theoretical activity in sputtering and radiation damage. I assume that news of this finding also went to the stopping community, where comparisons between electronic stopping of molecules and atoms were found to reveal a similar enhancement, even though on rather different grounds.

Many years later Hans Henrik spent a sabbatical year in Orsay, where a cluster-ion source had been installed at the tandem accelerator. Here he was able to report a more than tenfold nonlinear increase in sputter yields on silver and gold, probably the largest sputter yields measured on a metal.

In 1982 Hans Henrik was called to the University of Copenhagen for a chair in physics. He had been a member of the Danish Science Research Council for some years, and with his move to the capital he was the obvious candidate for chairmanship of the council. In this capacity he had to communicate with the minister and his administration at a time when research had low priority in the political system. After finishing his term Hans Henrik wanted to establish accelerator mass spectrometry as his main research activity, a project that he was highly qualified for, not only because of his experience in accelerators but just as much qua his longstanding interest in archeology which had been stimulated by his father.

There were no funds to finance this activity. As a consequence, Hans Henrik had to live with available facilities for many years. Within this restriction, however, he made his experience and knowledge available in numerous cooperations, most notably in a group studying antiproton physics at CERN and a local program dealing with solid noble-gas bubbles in metals which subsequently expanded into a study of immiscible alloys.

Hans Henrik became responsible for several years for the introductory physics course also in Copenhagen, and he soon became department head at the Ørsted Institute. At the same time he took over another major responsibility. Nuclear Instruments and Methods (NIM), edited by Kai Siegbahn, had been a publishing choice to a significant part of the ion-beam community for more than two decades. In particular, several ion-beam-oriented conferences had adopted NIM for their proceedings. The decision was made to split off topics related to ‘Beam Interactions with Materials and Atoms’ and to establish NIMB as a new journal with Hans Henrik Andersen and Tom Picraux as editors.

Hans Henrik had editorial experience from several years of coeditorship for Applied Physics A. With this background he administrated the task in a superb manner. Initially, conference proceedings provided the majority of published papers. That fraction has reduced but has always remained substantial. In addition to attending in person most of the conferences whose proceedings he published, Hans Henrik made a never ceasing effort to raise and maintain refereeing standards for both regular and conference papers.

On several occasions I had the opportunity to get insight into his practice when serving as a coeditor of conference proceedings. One striking experience was his loyalty to reviewers. Even when he felt that a reviewer’s recommendation to accept a paper could be questioned, he would rather accept the paper than override a reviewer’s judgement. His reasoning was that an author should not receive a less favorable treatment just because the editor happened to have detailed knowledge about the topic. One may agree or disagree to this attitude, but it may be one of the reasons why Hans Henrik was able to be a successful editor for almost thirty years.

Peter Sigmund